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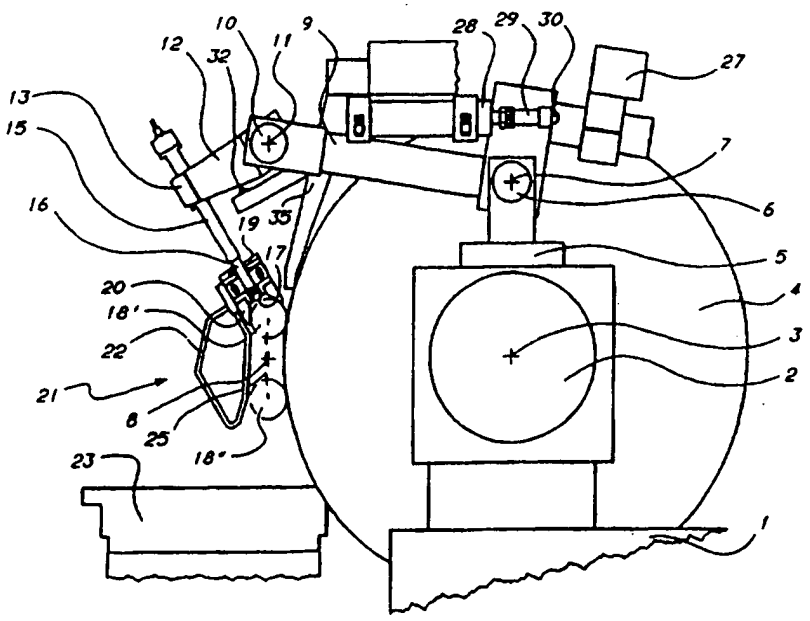
(54) Title: APPARATUS FOR CHECKING THE DIAMETER OF CRANKPINS ROTATING WITH AN ORBITAL MOTION



(57) Abstract

An apparatus for checking the diameter of crankpins (18) of a crankshaft (34) in the course of the machining in a grinding machine comprises a first arm (9) rotating with respect to a support (5) arranged on the grinding-wheel slide (1) of the grinding machine, a second arm (12) rotating with respect to the first, a reference device (20) carried by the second arm and a measuring device (16, 17, 40-45) associated with a reference device. A guide device (21), fixed to the reference device (20), enables the apparatus to engage a crankpin, in the course of the orbital motion of the crankpin, and limit the displacements of the first arm and those of the second arm when a control device (28-30) displaces the apparatus to a rest position.

DESCRIPTION

APPARATUS FOR CHECKING THE DIAMETER OF CRANKPINS ROTATING WITH AN ORBITAL MOTION

Technical Field

The present invention relates to an apparatus for checking the diameter of crankpins rotating with an orbital motion about a geometrical axis, in the course of the machining in a numerical control grinding machine including a worktable, defining said geometrical axis, and a grinding-wheel slide with a reference device for cooperating with the crankpin to be checked, a measuring device, movable with the reference device, and a support device for supporting the reference device and the measuring device, the support device having a support element, a first coupling element coupled to the support element so as to rotate about a first axis of rotation parallel to said geometrical axis, and a second coupling element carrying the reference device and coupled, in a movable way, to the first coupling element.

Background Art

US-A-4637144 discloses an apparatus for checking the diameter of crankpins orbiting about a geometrical axis, in the course of the machining in a grinding machine. The apparatus is supported by a support fixed to the worktable of the grinding machine, or by a support affixed to the bed of the grinding machine, or by a longitudital slide arranged on the worktable.

The apparatus comprises a reference device, Vee-shaped or of another type, for cooperating with the crankpin to be checked, a measuring head fixed to the reference device and provided with two movable arms carrying feelers for contacting diametrically opposite points of the crankpin, a

geometrical axis of the orbital motion. This machine and its associated checking devices are not suitable for checking during the machining operation, among other things owing to the fact that the guide and reference devices describe trajectories that essentially correspond to the orbital motion of the associated crankpin, the speed of the orbital motion is considerably lower with respect to that occurring in the course of the machining in a crankpin grinding machine and the displacement of the checking devices from a rest position to an operating condition occurs when the crankshaft is not rotating.

U.S. patent No. US-A-3386178 discloses an apparatus, for checking the diameter of cylindrical workpieces, rotating about their geometrical axis, in the course of the machining in a grinding machine. The apparatus comprises two arms, rotating reciprocally and with respect to the grinding-wheel slide. One of the arms supports two reference elements or fixed (with respect to the arm) feelers for contacting the surface of the rotating workpiece and a movable stem, with a feeler for contacting the workpiece and an opposite end for cooperating with the movable element of a clock comparator. The apparatus is manually displaced from a rest position to a measuring condition, and vice versa. The grinding machine cannot machine workpieces rotating with an orbital motion, nor is the measuring apparatus suitable for a similar type of application.

Disclosure of the Invention

Object of the present invention is to provide an apparatus for the metrological checking of crankpins rotating with an orbital motion, in the course of a grinding operation, or in a similar one, that can provide good metrological performance, high reliability and small forces of inertia.

This problem is solved by a measuring apparatus of the hereinbefore mentioned type, wherein the second coupling

considerably different nominal dimensions, and safety devices for preventing any collisions or unwanted and/or dangerous motions.

The characteristics of the apparatus and of its application in the grinding machine enable to combine remarkable functionality with relatively low costs and to obtain an arrangement of the apparatus that facilitates the loading and the unloading of the crankshafts and limits the layout dimensions in the areas surrounding the more critical elements of the grinding machine and the accessory devices, like the workpiece loading/unloading devices.

Brief Description of the Drawings

The invention is now described in more detail with reference to the enclosed drawings, showing a preferred embodiment by way of illustration and not of limitation. In said drawings:

figure 1 is a lateral view of a measuring apparatus mounted on the grinding-wheel slide of a grinding machine for crankshafts, in the highest position that the apparatus reaches during the grinding of a crankpin rotating with an orbital motion about the main axis of the crankshaft;

figure 2 is a similar view as that of figure 1, wherein the apparatus is in the lowest possible position it reaches in the course of the grinding of the crankpin;

figure 3 is a lateral view of the apparatus shown in figures 1 and 2 under a condition whereby the grinding machine numerical control has commanded a withdrawal of the grinding wheel for emergency reasons;

figure 4 is a lateral view showing the apparatus of figures 1-3 in the rest position;

figure 5 is a partial front view of the apparatus mounted on the grinding-wheel slide of the grinding machine;

figure 6 shows a detail of the measuring device of the apparatus for the comparative measurement of the diameter

guide casing **15** there is fixed a support block **19** supporting a reference device **20**, Vee-shaped, adapted for engaging the surface of the crankpin **18** to be checked, by virtue of the rotations allowed by pins **6** and **10**. The transmission rod **16** is movable along the bisecting line of the Vee-shaped reference device **20**.

The support block **19** further supports a guide device **21**, that, according to the following more detailed description, serves to guide the reference device **20** to engage crankpin **18** and maintain contact with the crankpin while the reference device **20** moves away from the crankpin, for limiting the rotation of the first **9** and of the second **12** coupling elements about the axes of rotation **7**, **11** defined by pins **6** and **10**. The guide device **21** consists of a metal rod **22** suitably bent in order to have a guide portion that can cooperate with crankpin **18**.

The crankshaft to be checked is positioned on the worktable **23**, between a spindle and a tailstock, not shown, that define the axis of rotation **8**, coincident with the main geometrical axis of the crankshaft. As a consequence, crankpin **18** performs an orbital motion about axis **8**. Reference number **18'** indicates the upper position that the crankpin reaches, whereas reference number **18''** indicates the crankpin lower position. Figures 1 and 2 show the positions of the measuring apparatus when the crankpin reaches the upper position **18'** and the lower one **18''**, respectively. Even though crankpin **18** rotates eccentrically about axis **8**, by describing a circular trajectory, the trajectory of the pin with respect to the grinding-wheel slide **1** can be represented, substantially, by an arc shown with a dashed line and indicated by reference number **25**. Thus, reference device **20** describes a similar trajectory, with a reciprocating motion from up to down and vice versa and at a frequency -of some tens of revolutions per minute- equal to that of the orbital motion of crankpin **18**. This is due to the fact that the checking apparatus is carried by the grinding-wheel slide **1** that, in modern numerical

30 contacts an abutment fixed to counterweight 27 and causes the displacement of the checking apparatus in the rest position shown in figure 4, according to which reference device 20 is arranged above the geometrical axis 8 and the crankpin upper position 18', with the bisecting line of the Vee substantially arranged in vertical direction. During this displacement, an abutting surface, fixed to the coupling element 12, enters into contact with a positive stop element 32, fixed to the coupling element 9, thus defining a minimum value of the angle formed between the two coupling elements 9 and 12, for the purpose of both preventing interferences with devices of the grinding machine and defining a rest position for enabling the displacing of the apparatus to the checking position to occur in the best possible way. The retraction of the checking apparatus to the rest position is normally controlled by the grinding machine numerical control when, on the ground of the measuring signal of the checking apparatus, it is detected that crankpin 18 has reached the required (diametral) dimension. Thereafter, the machining of other parts of the crankshaft takes place, or -in the event the machining of the crankshaft has been completed- the piece is unloaded, manually or automatically, and a new piece is loaded on worktable 23.

When a new crankpin has to be machined, it is brought in front of grinding wheel 4, usually by displacing the worktable 23 (in the event of a grinding machine with a single grinding wheel), and the checking apparatus moves to the measuring position. This occurs by controlling, by means of the grinding machine numerical control, cylinder 28 so that rod 29 is retracted. Thus, cap 30 disengages from the abutment of counterweight 27 and, through rotation of the coupling elements 9, 12, at first only about the axis of rotation 6 and thereafter also about the axis of rotation 11, due to the specific weight of the components of the checking apparatus, support block 19 approaches, by describing a trajectory with a mainly vertical component,

extending in a longitudinal direction and portions offset in different transversal planes.

Figures 6 and 7 show some details of the measuring device of the apparatus. In figure 6 there is shown a crankpin **18** featuring in the central part, as usual, a lubrication hole **38**. In order to avoid any interferences with the lubrication hole **38**, feeler **17** is offset with respect to the intermediate cross-section of pin **18**, by means of a transversal portion **40** of the transmission rod **16**.

The axial displacements of the transmission rod **16** with respect to a reference position are detected by means of a measurement transducer, fixed to the tubular casing **15**, for example a "cartridge" head **41** with a feeler **42** contacting an abutting surface formed in a second transversal portion **43** of the transmission rod **16**. In this way, feeler **17** and measuring head **41** along with feeler **42** are kept aligned along a measurement axis. As shown in figure 7, too, the axial displacement of the transmission rod **16** is guided by two bushings **44** and **45**, arranged between casing **15** and rod **16**. A metal bellows **46**, that is stiff with respect to torsional forces, and has its ends fixed to rod **16** and to casing **15**, respectively, accomplishes the dual function of preventing rod **16** from rotating with respect to casing **15** (thus preventing feeler **17** from undertaking improper positions) and sealing the lower end of casing **15**, whereto the coolant delivered by the nozzle of tube **35**, is directed.

The support block **19** is secured to the guide casing **15** by means of screws **50** passing through slots **51** and supports the reference device **20**, consisting of two elements **52**, **53** with sloping surfaces, whereto there are secured two bars **54**, **55**. In the area **57**, the guide tubular casing **15** is secured to the free end of the coupling element **12**, for example, as hereinbefore mentioned, by means of a tie coupling **13**, not shown in figure 7. The tie coupling **13** enables rough axial adjustments, in the direction of the bisecting line of the Vee defined by bars **54**, **55**, in order

counterbalancing effect, similar to the one of the counterweight **27** of figures 1-5, allowing to establish a proper engagement force between the Vee reference device **20** and the crankpin **18** to be checked.

When, in order to permit displacement of the apparatus to the checking condition, rod **29** is retracted, and cap **30** disengages from the abutment, or idle wheel **72**, support block **19** approaches the crankpin **18** through rotation of the coupling elements **9**, **12**, and the apparatus operates as described hereinabove with reference to figures 1 to 5. The cooperation between crankpin **18** and reference device **20** is maintained, as above described, owing to the displacements of the components caused by the force of gravity.

The action of the coil spring **73**, the stretching of which increases with the lowering of the support block **19**, partially and dynamically counterbalances the forces due to the inertia of the moving parts of the checking apparatus following the displacements of the crankpin **18**.

In such a way, it is possible, for example, to avoid overstresses between the reference device **20** and the crankpin **18**, in correspondence of the lower position **18''**, that might tend to move apart the sides of the Vee of the reference device **20**. On the other side, since during the raising movement of the apparatus (due to rotation of the crankpin towards the upper position **18'**) the pulling action of the spring **73** decreases, the inertial forces tending, in correspondence of the upper position **18'**, to release the engagement between the Vee reference device **20** and the crankpin **18**, can be properly counterbalanced. In the latter case, it is pointed out that the counterbalancing action is obtained, by means of the spring **73**, through a decreasing of its pulling action. In other words, the coil spring **73** does not cause any pressure between the reference device **20** and the crankpin **18**, that mutually cooperate, as above mentioned, just owing to the force of gravity.

It is possible to equip one of the above described checking apparatuses with further feelers, associated transmission

CLAIMS:

1. Apparatus for checking the diameter of crankpins (18) rotating with an orbital motion about a geometrical axis (8), in the course of the machining in a numerical control grinding machine including a worktable (23), defining said geometrical axis, and a grinding-wheel slide (1), movable in a transversal direction, with a reference device (20) for cooperating with the crankpin to be checked, a measuring device (16, 17, 40-45) movable with the reference device, and a support device for supporting the reference device and the measuring device, the support device having a support element (5), a first coupling element (9) coupled to the support element so as to rotate about a first axis of rotation (7) parallel to said geometrical axis (8), and a second coupling element (12) carrying the reference device (20) and coupled, in a movable way, to the first coupling element (9), characterized in that the second coupling element (12) is coupled to the first coupling element (9) in such a way as to rotate with respect to it about a second axis of rotation (11) parallel to said geometrical axis (8), the support element (5) is fixed to the grinding-wheel slide (1), and the apparatus comprises a guide device (21) associated with the reference device (20) for guiding the arrangement of the reference device on the crankpin (18) in the course of said orbital motion, and a control device (28-30) for enabling the apparatus to displace in an automatic way from a rest position to a checking condition, and vice versa.

2. An apparatus according to claim 1, wherein, in said rest position, the reference device (20) is arranged substantially above said geometrical axis (8) and, in the displacement from the rest position to the checking condition, describes a trajectory (25) with a prevailing vertical component.

crankpins (18).

10. An apparatus according to one of claims 1 to 9, comprising a counterweight (27) coupled to said first coupling element (9), the reference device (20) being adapted for maintaining contact with the crankpin to be checked (18), substantially owing to the forces of gravity.

11. An apparatus according to one of claims 1 to 9, comprising a spring (73) arranged between said support element (5) and said first coupling element (9), the reference device (20) being adapted for maintaining contact with the crankpin to be checked (18), substantially owing to the forces of gravity.

12. An apparatus according to claim 12, wherein said spring (73) is arranged between said support element (5) and said first coupling element (9) to apply to the reference device (20) a pulling action tending to release said contact with the crankpin to be checked (18).

13. An apparatus according to claim 12, wherein said spring is a return spring (73).

14. An apparatus according to one of claims 10 to 13, comprising an abutment (27;72) connected to the first coupling element (9), wherein said control device comprises a movable element (29, 30) for cooperating with said abutment (27:72) for bringing and keeping the apparatus in the rest position.

15. An apparatus according to claim 14, wherein said control device comprises a double-acting cylinder (28).

16. An apparatus according to one of claims 1 to 15, comprising a detecting device (60) for detecting the presence of the workpiece to be checked (34) in the

comprises a metal bellows (**46**) having its ends fixed to the transmission rod and to the guide casing, respectively.

22. An apparatus according to claim 20 or claim 21, comprising two bushings (**44, 45**) arranged between the guide casing (**15**) and the transmission rod (**16**), for centering and guiding the transmission rod with respect to the guide casing.

23. An apparatus according to one of claims 20 to 22, wherein said reference device (**20**) is fixed in a dismantable way to said guide casing (**15**).

24. An apparatus according to one of the claims 20 to 23, wherein said second coupling element comprises said guide casing (**15**) and an arm (**12**), substantially perpendicular to the guide casing, coupled in a rotating way to the first coupling element (**9**).

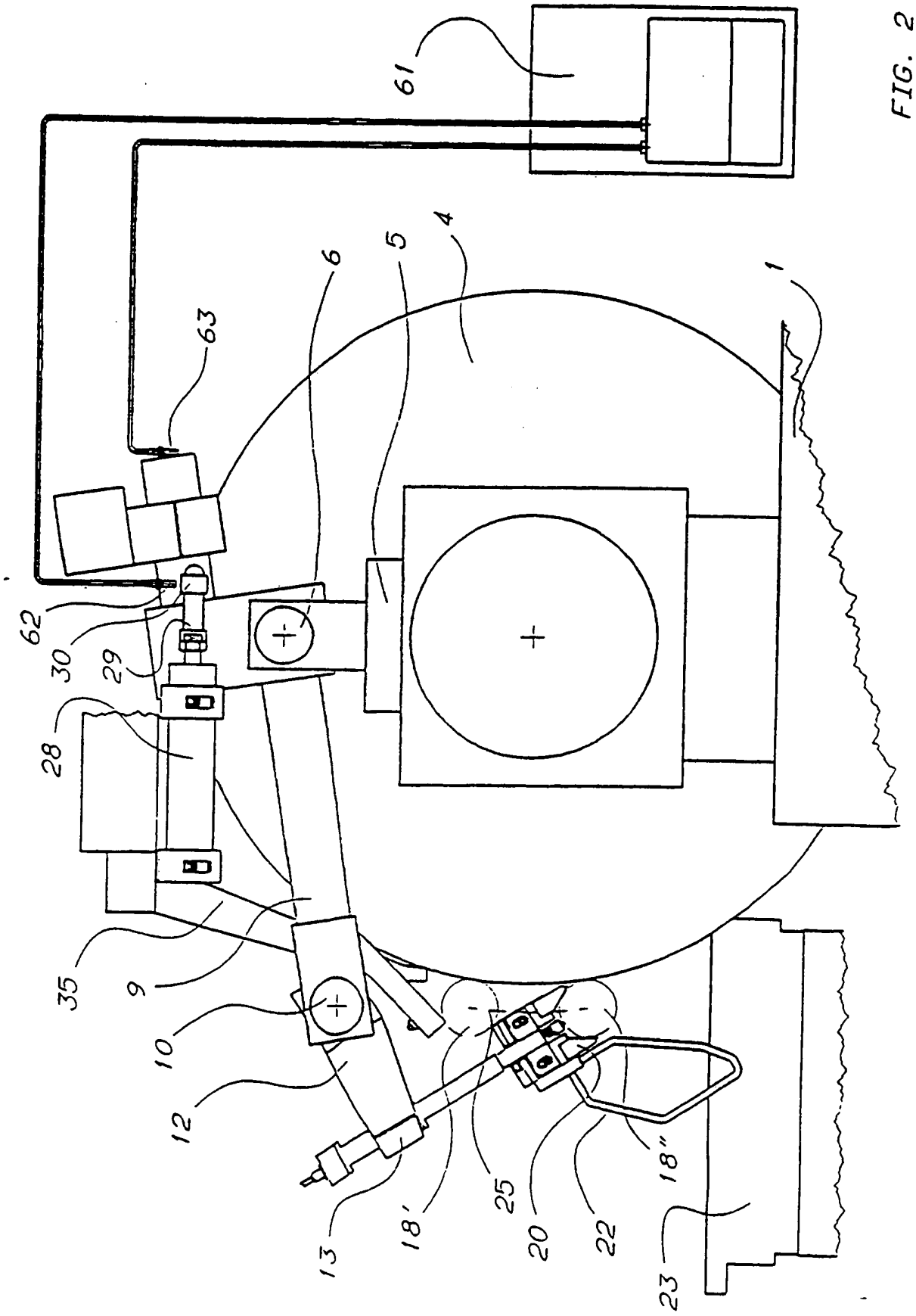


FIG. 2

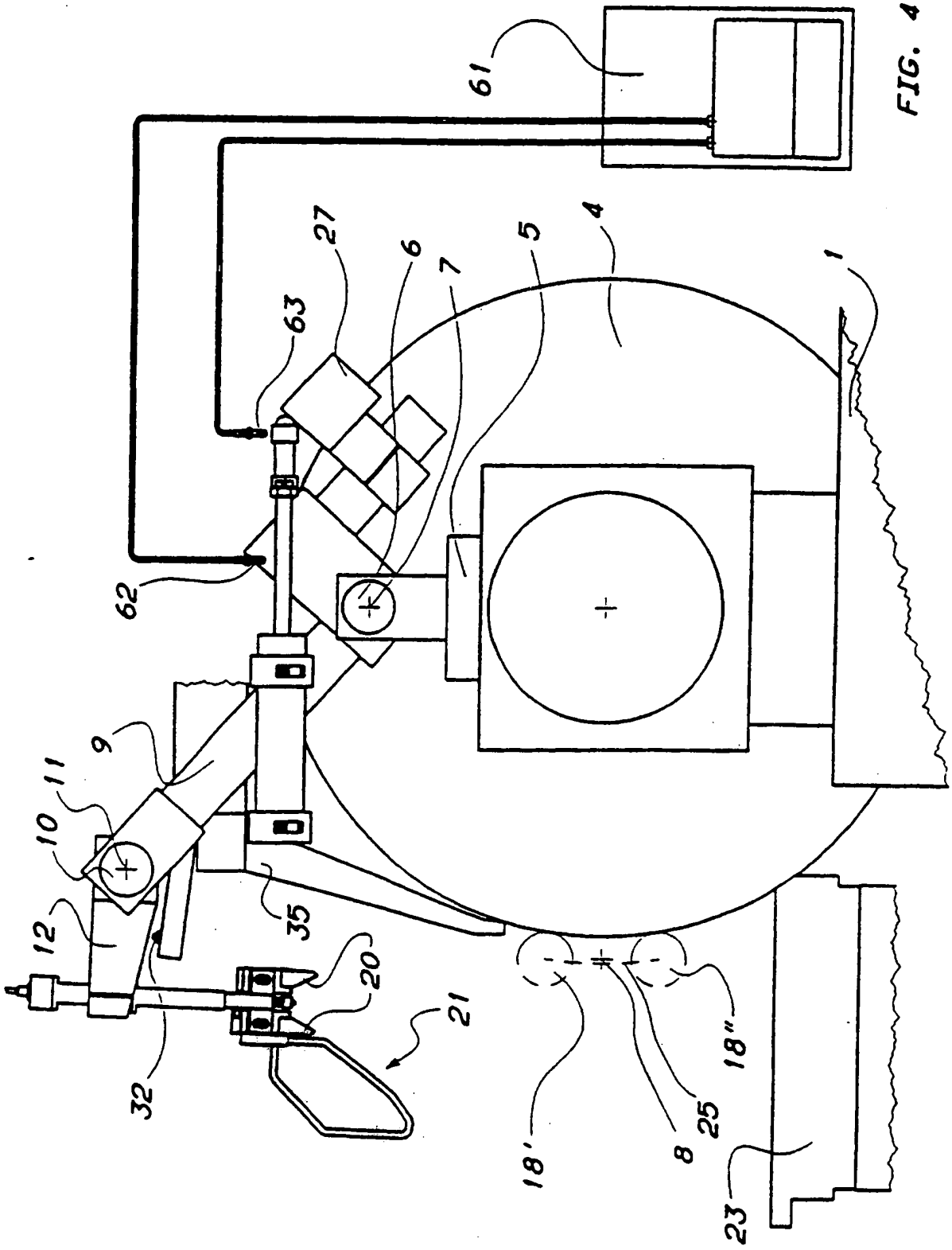


FIG. 4

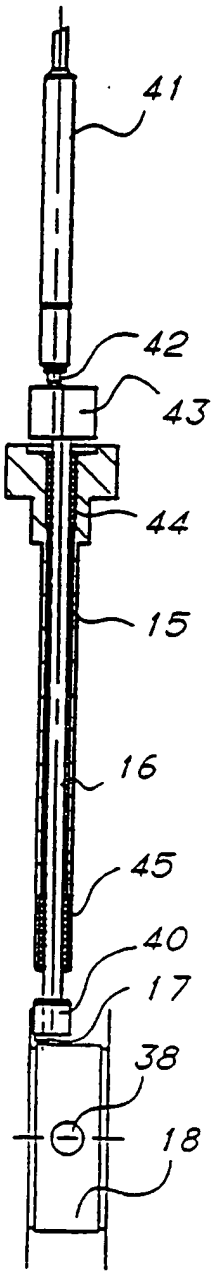

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FIG. 6

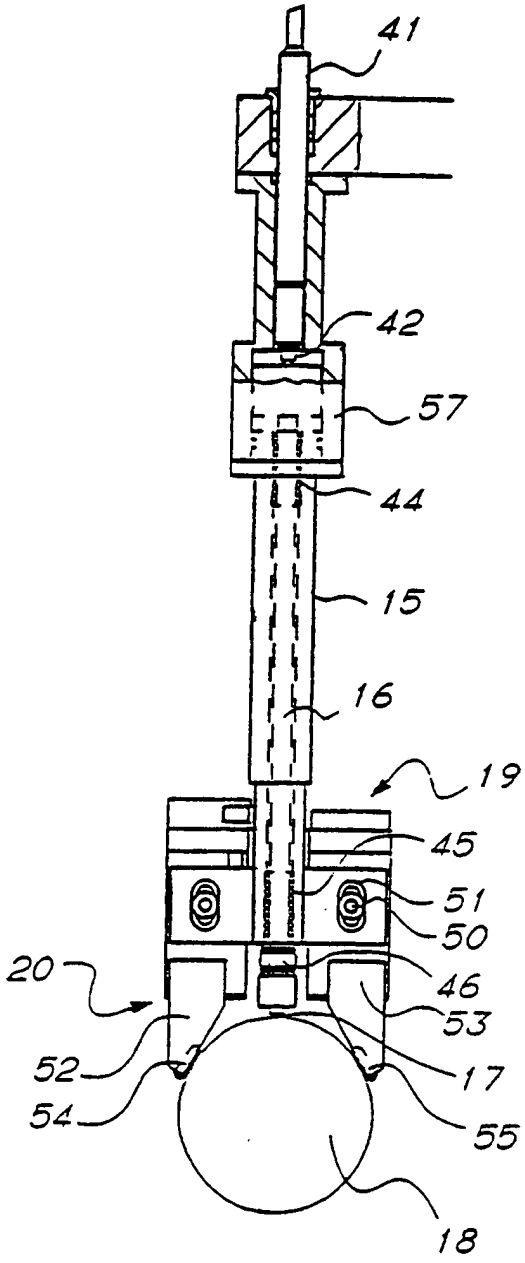
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FIG. 7

INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/EP 96/04147

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B24B5/42 B24B49/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B24B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	GB,A,1 362 996 (LITTON INDUSTRIES, INC.) 14 August 1974	1-4,7-24
A	see page 2, line 23 - page 3, line 122; claims 1-14; figures 2,3,7	5,6

Y	FR,A,756 177 (NORTON COMPANY) 6 December 1933	1-4,7-24
A	see claims 1-20; figures 1,2	5,6

A	US,A,1 941 456 (P.S. ARNOLD) 2 January 1934	1-13
	see claim 1; figure 1	

A	US,A,4 637 144 (ROLAND SCHEMEL) 20 January 1987	1
	cited in the application	
	see abstract; figures 1,2	

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
19 December 1996	10. 01. 97

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INTERNATIONAL SEARCH REPORT

information on patent family members

Int[illegible]onal Application No
PCT/EP 96/04147

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